

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
13 February 2003 (13.02.2003)

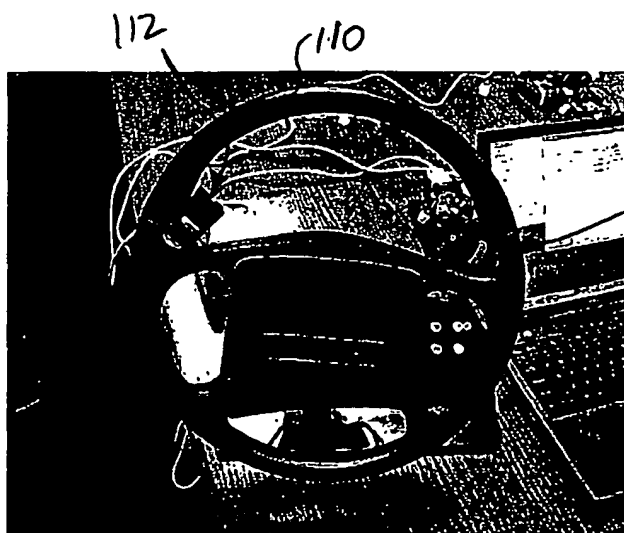
PCT

(10) International Publication Number
WO 03/012557 A2

- (51) International Patent Classification⁷: G05B (74) Agents: LEMON, Kevin, T. et al.; Townsend and Townsend and Crew LLP, Two Embarcadero Center, Eighth Floor, San Francisco, CA 94111-3834 (US).
- (21) International Application Number: PCT/US02/24420
- (22) International Filing Date: 31 July 2002 (31.07.2002) (81) Designated States (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZM, ZW.
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:
60/309,390 31 July 2001 (31.07.2001) US
Not furnished 29 July 2002 (29.07.2002) US
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- (84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).
- Declaration under Rule 4.17:
— of inventorship (Rule 4.17(iv)) for US only
- Published:
— without international search report and to be republished upon receipt of that report

[Continued on next page]

(54) Title: CONTROL WHEEL WITH HAPTIC FEEDBACK



(57) Abstract: A control wheel for controlling at least one function of a system by a user includes a moveable engagement wheel for engagement by the user and an actuator coupled to the engagement wheel for providing force or haptic feedback to the engagement wheel in response to movement of the engagement wheel. A sensor for sensing movement of the engagement wheel is provided and a control system is coupled to the sensor for receiving information about positioning and movement of the engagement wheel, and is also coupled to the actuator for controlling force to the engagement wheel. The control system also provides control of the at least one function of the system.

WO 03/012557 A2



For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

CONTROL WHEEL WITH HAPTIC FEEDBACK

CROSS-REFERENCES TO RELATED APPLICATIONS

- 5 [0001] This application claims priority to U.S. Provisional Application No. 60/309,390 (Attorney Docket No. 021360-023900US) filed July 31, 2001 which is herein incorporated by reference for all purposes.

STATEMENT AS TO RIGHTS TO INVENTIONS MADE UNDER 10 FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[0002] NOT APPLICABLE

REFERENCE TO A "SEQUENCE LISTING," A TABLE, OR A COMPUTER PROGRAM LISTING APPENDIX SUBMITTED ON A COMPACT DISK.

15 [0003] NOT APPLICABLE

BACKGROUND OF THE INVENTION

[0004] This invention relates generally to wheel control devices, and more particularly to
20 control wheel devices including haptic feedback.

[0005] Control wheels and knobs are used for a variety of different functions on many different types of devices. Often, rotary control knobs offer a degree of control to a user that is not matched in other forms of control devices, such as button or switch controls. For
25 example, many users prefer to use a rotating control knob to adjust the volume of audio output from a stereo or other sound output device, since the knob allows both fine and coarse adjustment of volume with relative ease, especially compared to button controls. Wheels and knobs are used on a variety of other types of devices, such as kitchen and other home appliances, video editing/playback devices, remote controls, televisions, etc.

30 [0006] Some control wheels have been provided with "force feedback." Force feedback devices can provide physical sensations to the user manipulating the knob. Typically, a

motor is coupled to the wheel and is connected to a controller such as a microprocessor. The microprocessor receives sensor signals from the wheel and sends appropriate force feedback control signals to the motor so that the motor provides forces in the rotary degree of freedom of the wheel. In this manner, a variety of programmable feel sensations can be output on the
5 wheel, such as detents, spring forces, or the like.

SUMMARY OF THE INVENTION

[0007] In accordance with one aspect of the present invention, a control wheel for
10 controlling at least one function of a system by a user, includes a moveable engagement wheel for engagement by the user and an actuator coupled to the engagement wheel for providing force or haptic feedback to the engagement wheel in response to movement of the engagement wheel. A sensor for sensing movement of the engagement wheel is provided and a control system is coupled to the sensor for receiving information about positioning and
15 movement of the engagement wheel, and also coupled to the actuator for controlling force to the engagement wheel. The control system also provides control of the at least one function of the system.

[0008] In accordance with another aspect of the present invention, the engagement wheel is
20 coupled to the actuator via a gear drive transmission comprising an internal gear within the engagement wheel and a gear pinion coupled to the actuator via a shaft, the internal gear being meshed with the gear pinion.

[0009] In accordance with a further aspect of the present invention, the engagement wheel
25 is coupled to the actuator via a belt coupled to a shaft of the actuator.

[0010] In accordance with yet another aspect of the present invention, the engagement wheel is directly coupled to a shaft of the actuator.

30 [0011] In accordance with a further aspect of the present invention, the engagement wheel is coupled to the actuator by contacting a pinion coupled to a shaft of the actuator.

[0012] In accordance with another aspect of the present invention, the engagement wheel is coupled to the actuator via a flexible coupling.

[0013] In accordance with a further aspect of the present invention, the actuator comprises a DC motor.

5 [0014] In accordance with yet another aspect of the present invention, the sensor comprises an optical encoder comprising an optical encoder disk and an emitter/detector.

[0015] In accordance with a further aspect of the present invention, the sensor comprises one of an analog potentiometer, a capacitive sensor, and a reflective emitter/detector and
10 encoder bar.

[0016] In accordance with another aspect of the present invention, the control wheel further comprises a switch shaft, and a switch guide in engagement with the switch shaft and coupled to the engagement wheel such that a switch is engageable by depressing the engagement
15 wheel.

[0017] Other features and advantages of the present invention will be understood upon reading and understanding the description of the preferred exemplary embodiments, found hereinbelow, in conjunction with reference to the drawings, in which like numerals represent
20 like elements.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] Figures 1A and 1B are perspective views of steering wheel configurations with a
25 haptic scroll wheel in accordance with the present invention;

[0019] Figure 1C is a close-up plan view of a user engaging the haptic scroll wheel in accordance with the present invention;

30 [0020] Figure 2A is a front plan view of a haptic scroll wheel in accordance with the present invention;

[0021] Figure 2B is a perspective view of the haptic scroll wheel illustrated in Figure 2A;

[0022] Figure 2C is an exploded view of the haptic scroll wheel illustrated in Figures 2A and 2B;

5 [0023] Figure 2D is a further exploded view of the haptic scroll wheel illustrated in Figures 2A and 2B;

[0024] Figure 2E is a schematic view of a sensor assembly for use with the haptic scroll wheel in accordance with the present invention;

10 [0025] Figure 3 is a perspective view of an alternative embodiment of a haptic scroll wheel in accordance with the present invention;

[0026] Figures 4A and 4B are plan and exploded views, respectively, of a further alternative embodiment of a haptic scroll wheel assembly in accordance with the present invention;

15

[0027] Figure 5A is a plan view of another alternative embodiment of a haptic scroll wheel assembly in accordance with the present invention;

20 [0028] Figure 5B is an exploded view of the haptic scroll wheel assembly illustrated in Figure 5A;

[0029] Figure 6 is a perspective view of another alternative embodiment of a haptic scroll wheel assembly in accordance with the present invention; and

25 [0030] Figure 7 is a chart illustrating several different embodiments with categories of actuators, subject transmissions, select switch motors, sensors and power transmissions that may be used with scroll wheel assemblies in accordance with the present invention.

30 DESCRIPTION OF SPECIFIC PREFERRED EXEMPLARY EMBODIMENTS

[0031] A goal of a haptic scroll wheel disclosed herein is to allow the user to intuitively control several interface modes of a computer or electronic device with a single scroll wheel. That is, by adjusting the feel of the scroll wheel to clearly correspond to the context of the

user interface, users may more easily navigate through complex computer-implemented menus and modes. For example, some interface modes may have the tactile feel of detents, while other modes may have the spring centered feel of a jog-shuttle. By providing familiar haptic metaphors, this variable feedback affords a cleaner, richer user experience.

5

[0032] One preferred application for the haptic scroll wheel is in a vehicle such as an automobile. The haptic scroll wheel can be conveniently positioned on, for example, a steering wheel of the automobile so that the driver can easily access the scroll wheel. In other embodiments, the scroll wheel can be placed on the dashboard of the vehicle or other
10 location, allowing driver and/or passengers to control functions using the scroll wheel via a control system. The device 10 can also control vehicular functionality such as audio control and output, temperature control, window control, seat control, navigation system, cellular telephone or other portable telephone control system, security/alarm system, etc.

15 [0033] In still other embodiments, the scroll wheel can be used for other devices, such as computer interface devices (mice, joysticks, trackballs, steering wheels, medical simulation devices, etc.), stereos, televisions, computers (e.g. Internet navigation), appliances, editing/playback devices, remote controls for any device, a home automation system (to control such devices as lights, garage doors, locks, appliances, etc.), telephones,
20 photocopiers, control devices for remotely-controlled model vehicles, toys, etc.

[0034] Although the device of the present invention is referred to as a "scroll wheel" herein and scrolling lists and other linear structures of data is one of its intended purposes, the wheel can be used for other control functions as well besides scrolling, such as moving a displayed
25 cursor, adjusting a volume, balance, setting, or other value, etc.

[0035] Many different embodiments for device features, control modes, controller electronics, and haptic effects for wheels, knobs, and other devices, most of which can be used with the present invention, are described in Patent Nos. 6,128,006 and 6,154,201 and
30 copending application nos. 09/783,936 and 09/637,513, all of which are incorporated herein by reference in their entirety for all purposes.

[0036] Figures 1a and 1b show two steering wheel configurations for the haptic scroll wheel of the present invention in a prototype form. The steering wheel 100 of Figure 1a can

be in a vehicle such as an automobile, boat, etc. The haptic scroll wheel 102 can be positioned near the side of the wheel, near to the location where a user's hand grips the wheel 100. This allows the user to easily move a finger over to the wheel from a natural grip location. The steering wheel 110 of Figure 1b includes two haptic wheels 112 and 114, on
5 opposing sides of the steering wheel. This allows the user to use the particular scroll wheel that feels more comfortable, or allows the user to simultaneously use two scroll wheels to control two functions at once. An example of the size of a scroll wheel assembly illustrated in Figures 1a-1c is 30mm x 40mm x 50mm.

10 [0037] The orientation of a haptic wheel on a steering wheel as shown in Figures 1a and 1b can be varied in different embodiments. The axis of rotation of the haptic scroll wheel can be made parallel to the long axis of the thumb when the user grips the steering wheel, allowing the user to move the haptic wheel side to side. This configuration is shown in Figure 1c. This orientation keeps the user's thumb extended and allows the haptic effects to be easily
15 felt. In other embodiments, the haptic wheel can be positioned so that its axis of rotation is perpendicular to the long axis of the thumb, so that the user moves the haptic wheel up and down by bending the thumb. The perpendicular orientation may provide the user with greater control over the haptic wheel, but may cause some forces to feel asymmetric because the thumb is less stiff when it is extended versus when it is contracted.

20 [0038] Because the scroll wheel is mounted to a vehicle steering wheel that rotates, the scroll wheel will be presented to the user in a variety of different orientations. For example, the scroll wheel will be in a different orientation when the user is driving down the freeway than when the car is parked with the wheel at an angle or upside down. Because the user will
25 be primarily using the device driving straight down the road, placement and orientation of the device should be optimized for that mode of use. However, the other modes of use (i.e. parked) should be kept in mind when designing the system, and the orientation shown in Figure 1c sufficiently addresses these other modes.

30 [0039] One preferred embodiment of the haptic scroll wheel is described with reference to Figures 2a-2e. Figures 2a and 2b show the scroll wheel device assembled, while Figures 2c and 2d show an exploded view. Figure 2e is a view of the encoder assembly. This embodiment provides a small volume, low cost, and high fidelity haptic effects.

[0040] The user contacts the scroll wheel 120. The wheel 120 preferably has a frictional outer surface to engage the user's skin sufficiently such the user can experience the haptic effects. The wheel 120 is preferably a DC Motor 122 (or other type of actuator) that is coupled to the wheel 120 via a gear drive transmission that amplifies the maximum drive force of the motor. The gear drive transmission includes an internal gear 124 and a gear pinion 126. The internal gear 124 includes teeth provided on the interior of the wheel 120 which mate with the teeth of pinion 126. The wheel 120 and internal gear 124 are located relative to the gear pinion 126 via a wheel shaft 128 which is rigidly coupled to the rotational center of wheel 120.

[0041] A desirable power transmission ratio for haptic feedback is between 2.5-4. Lesser ratios tend to cause the system to be inherently unstable and some form of friction must then be built in to add damping and thus stability. Greater ratios tend to cause the inertia of the motor to interfere with the haptic experience. In other embodiments, instead of an internal gear 124 and a gear pinion 126, the gears could be replaced with friction elements, eliminating backlash, e.g. a frictional ring can be provided instead of internal gear 124 and pinion 126 can instead be a friction wheel made of, for example, rubber.

[0042] As may be seen in Figures 2d and 2e, the rotational position of the scroll wheel 120 is preferably sensed by an optical encoder. An optical encoder disk 130 is rotated effectively by two transmission ratios. The encoder transmission 132 is coupled to the gear pinion 126 via a an o-ring belt 134 which is wrapped between a drive pulley 133 and an encoder pulley 135 and which provides an additional transmission ratio on top of the ratio provided between the internal gear 124 and the gear pinion 126. This allows a very low cost encoder emitter/detector 136 and optical encoder disk 130 to be used, e.g. a low sensing resolution can be increased through the use of the transmission ratios. The encoder disk 130 includes several slots (or marks) through which the emitted beam from emitter/detector 136 is directed, so that the detector of the emitter/detector 136 can detect the motion of the slots and thus the position of the wheel. With more expensive encoder technology the encoder transmission 132 is not needed and could be directly coupled to the internal gear/pinion transmission, e.g. coupled directly to the pinion 126. Emitter/detector 136 is in communication with the control system via connection 137. Other types of connection and communication may be used.

[0043] Additionally, there is the ability for the scroll wheel to be pushed by the user to allow additional commands. For example, the wheel can be pushed to select a particular entry in a list that has been scrolled by rotating the wheel. While in normal scroll wheel applications (i.e. mice) the method of actuation is less important, in haptic applications the method of actuation is very important because the use of barriers and springs can cause mis-actuation if not designed properly. A linear push select methodology is a preferred solution for these types of devices, although other select methodologies can be used.

[0044] Accordingly, the scroll wheel assembly 139 includes the wheel 120 and drive/transmission/sensor components. The assembly 139 is coupled to a base 138 via a push select shaft guide 140 and a push select shaft 142. The assembly is coupled to guide 140 via, for example, screws, rivets, etc. This allows the entire assembly 139 to move linearly along the shaft 142. Two select motion guides 144 are provided in the base 138 to guide the scroll wheel assembly 139 to move only along the axis of the select shaft 142. The assembly 139 rests on a tactile switch 146 so that when the assembly is depressed by the user (by pressing the wheel 120), the tactile switch 146 is closed. The tactile switch is in communication with the control system. Thus, selections may be made as the wheel is scrolled by a user, thereby moving the user through a computer displayed menu, an audible menu, a non-displayed menu, or a combination thereof, by depressing the scroll assembly and thereby engaging the tactile switch.

[0045] Figure 3 is a perspective view of another embodiment 150 of a haptic scroll wheel. A base 152 grounds an actuator 154, such as a DC motor, having a rotating shaft 156. A belt drive transmission includes a belt 156 which is wrapped around shaft 158 at one end and wrapped around a pulley 160 at its other end. A scroll wheel 162 is rigidly coupled to the pulley 160 and rotates about the same axis of rotation. The scroll wheel 162 can be made bigger than pulley 160 in other embodiments to allow easy access by the user; or, the scroll wheel 162 can be located further away from the pulley 160 along a shaft, for example. A digital encoder sensor includes an encoder disk 164 and emitter/detector 166 for sensing the position of the actuator shaft and scroll wheel 162. In other embodiments, the belt 156 can also be the contact surface for the scroll wheel, i.e. the user contacts the belt 156 when rotating the scroll wheel, and the scroll wheel would be the pulley 160 in such an embodiment.

[0046] Figure 4a is a perspective view of a direct drive embodiment 170 of a scroll wheel. An actuator 172, such as a DC motor, is grounded through a base 174. A scroll wheel 176 is connected directly to the shaft of the actuator 172. Since there is no transmission, this embodiment is one of the lowest cost embodiments of the scroll wheel device disclosed herein. Figure 4b is an exploded view of another direct drive configuration 175 including a base 176, scroll wheel 177, actuator 178, and encoder disk 179. The embodiments tend to have lower friction, and greater simplicity, but output lower amounts of torque.

[0047] Figure 5a is a perspective view and Figure 5b is an exploded view of another embodiment 180 of the scroll wheel, a friction/shear drive embodiment. The housing 182 holds the scroll wheel 184 and an actuator 186, where the shaft of the actuator is offset from the axis of rotation of the scroll wheel 184. The scroll wheel 184 is driven from its outer perimeter by a pinion 188 coupled to the actuator shaft 187. The surface of the scroll wheel 184 can be made resilient or frictional so as to engage the pinion 188 more readily. An encoder disk 190 can be coupled to the actuator shaft, e.g. on the other side of the scroll wheel from the actuator, so that an emitter/detector 191 can sense the position of the scroll wheel. Since the rotation axis of the actuator shaft is further from the rotation axis of the scroll wheel, a larger actuator can be used than if the actuator shaft were coincidental with the wheel axis. This embodiment tends to provide high torque output, scaleable mechanical design, and allows a smaller motor to be used while providing increased sensing resolution due to the friction transmission. Disadvantages include a high friction and more complexity than a direct drive configuration.

[0048] Figure 6 is a perspective view of another embodiment 200 of an off-axis-driven scroll wheel of the present invention. This embodiment provides a direct drive configuration with the rotary axis of the scroll wheel being different from the axis of the actuator shaft. An actuator 204 is grounded through a base 202. A scroll wheel 206 is rotationally coupled to the base 202 and is oriented with an axis of rotation nonparallel to the axis of rotation of the actuator shaft. A flexible coupling 208 connects the scroll wheel 206 with the actuator shaft to allow the actuator to drive the scroll wheel. In this configuration, a larger motor can easily be fit into available space.

[0049] Figure 7 is a chart illustrating several different embodiments of categories of actuators, sensor transmissions, select switch motors, sensors, and power transmissions which

can be used in the present invention, some of which are described in greater detail above. Any embodiments from a category can be used with any of the embodiments from another category. For actuators, a standard DC motor 210, a double D DC motor 212, a double shaft DC motor 214, an extended DC motor 216, or a moving magnet actuator 218 can be used.

5 Other actuator types that are not shown may also be used.

[0050] For sensor transmissions, the scroll wheel edge can rotate an encoder disk shaft in embodiment 220. Or, as shown in embodiment 222, a belt can connect the encoder disk to the scroll wheel or a pulley connected to the scroll wheel or actuator shaft. An internal gear and pinion connected to encoder disk can be used as shown in embodiment 224. A larger encoder disk with coarser resolution but lower cost can be used, or a smaller disk with greater resolution and cost can be used, as indicated in box 226. Or, a gear sensor transmission can be used, where the scroll wheel is coupled to a gear, and the encoder wheel is coupled to a pinion that engages the gear, as shown in embodiment 228.

10

15 [0051] Different select switch motions can be implemented. Embodiments 230 and 232 provide a scroll wheel that rotates or pivots about an axis of rotation as shown; for example, a base can be coupled to a pivoting portion that holds the scroll wheel. Embodiment 234 provides a translating scroll wheel, while embodiment 236 includes a grounded four-bar linkage that allows the scroll wheel to move approximately rotationally. Embodiment 238 provides a number of switches on the interior of the scroll wheel, so that the user can press the scroll wheel at any point on its circumference and the switch nearest to the point of contact senses the pressure, contact, or corresponding motion of the wheel.

20

25 [0052] Different types of sensors can be used, including an optical encoder including encoder disk and emitter/detector as shown in embodiment 240. An analog potentiometer as shown for embodiment 242, a capacitive sensor in embodiment 244 (as described in copending application no. 09/248,177, incorporated herein by reference for all purposes), a reflective emitter/detector and encoder bar with a pattern as shown in embodiment 246, and a pattern or other detectable surface provided on the encoder wheel itself and emitter and detector to sense motion, as shown for embodiment 248.

30

[0053] For power transmissions, a friction wheel (pinion) and frictional inner surface of the scroll wheel can be used, as shown in embodiment 250. Or, an internal gear and pinion can

be used, as described above and in embodiment 252. A direct drive embodiment 254 can also be used, or a belt drive embodiment 256. The off-axis embodiment 258 is also shown. These embodiments are described in greater detail above. Generally, while power transmissions produces greater torque, they also introduce higher friction, inertia and backlash, all of which potentially degrade the user experience. These trade offs must be kept in mind when designing a system that utilizes a power transmission.

[0054] While this invention has been described in terms of several preferred exemplary embodiments, there are alterations, modifications, and permutations thereof which fall within the scope of this invention. It should also be noted that the embodiments described above can be combined in various ways in a particular implementation. Furthermore, certain terminology has been used for the purposes of descriptive clarity, and not to limit the present invention.

15

WHAT IS CLAIMED IS:

- 1 1. A control wheel for controlling at least one function of a system by a
2 user, the control wheel comprising:
3 A moveable engagement wheel for engagement by the user;
4 An actuator coupled to the engagement wheel for providing force to the
5 engagement wheel in response to movement of the engagement wheel;
6 Sensing means for sensing movement of the engagement wheel; and
7 A control system coupled to the sensing means for receiving information
8 about positioning and movement of the engagement wheel, and also coupled to the actuator
9 for controlling force to the engagement wheel, the control system also providing control of
10 the at least one function of the system.
- 1 2. A control wheel in accordance with claim 1 wherein the engagement
2 wheel is coupled to the actuator via a gear drive transmission comprising an internal gear
3 within the engagement wheel and a gear pinion coupled to the actuator via a shaft, the
4 internal gear being meshed with the gear pinion.
- 1 3. A control wheel in accordance with claim 1 wherein the engagement
2 wheel is coupled to the actuator via a belt coupled to a shaft of the actuator.
- 1 4. A control wheel in accordance with claim 1 wherein the engagement
2 wheel is coupled to the actuator via a pulley coupled to a belt coupled to a shaft of the
3 actuator.
- 1 5. A control wheel in accordance with claim 1 wherein the engagement
2 wheel is directly coupled to a shaft of the actuator.
- 1 6. A control wheel in accordance with claim 1 wherein the engagement
2 wheel is coupled to the actuator by contacting a pinion coupled to a shaft of the actuator.
- 1 7. A control wheel in accordance with claim 1 wherein the engagement
2 wheel is coupled to the actuator via a flexible coupling.
- 1 8. A control wheel in accordance with claim 1 wherein the actuator
2 comprises a DC motor.

1 9. A control wheel in accordance with claim 1 wherein the sensing means
2 comprises an optical encoder comprising an optical encoder disk and an emitter/detector.

1 10. A control wheel in accordance with claim 1 wherein the sensing means
2 comprises one of an analog potentiometer, a capacitive sensor, and a reflective
3 emitter/detector and encoder bar.

1 11. A control wheel in accordance with claim 1 further comprising a
2 switch shaft, and a switch guide in engagement with the switch shaft and coupled to the
3 engagement wheel such that a switch is engageable by depressing the engagement wheel.

1 12. A control wheel for controlling at least one function of a system by a
2 user, the control wheel comprising:
3 A base including a push select shaft;
4 A scroll wheel assembly comprising:
5 A moveable scroll wheel for engagement by the user, the scroll wheel
6 comprising an internal gear provided within an interior of the scroll wheel;
7 An actuator comprising a drive shaft providing force to the scroll wheel in
8 response to movement of the scroll wheel;
9 a gear pinion coupled to the shaft and meshed with the internal gear; and
10 Sensing means for sensing movement of the scroll wheel;
11 A push select shaft guide in engagement with the push select shaft and
12 coupled to the scroll wheel assembly;
13 A tactile switch in engagement with the scroll wheel assembly; and
14 A control system coupled to the sensing means for receiving information
15 about positioning and movement of the scroll wheel, and also coupled to the actuator for
16 controlling force to the scroll wheel, the control system also providing control of the at least
17 one function of the system based upon the tactile switch and the scroll wheel.

1 13. A control wheel in accordance with claim 12 wherein the actuator
2 comprises a DC motor.

1 14. A control wheel in accordance with claim 12 wherein the sensing
2 means comprises an optical encoder comprising an optical encoder disk and an
3 emitter/detector.

1 15. A control wheel in accordance with claim 12 wherein the sensing
2 means comprises one of an analog potentiometer, a capacitive sensor, and a reflective
3 emitter/detector and encoder bar.

1 16. A steering wheel system for a motor vehicle system, the steering wheel
2 system comprising:

3 A control wheel for controlling at least one function of the motor vehicle
4 system by a user, the control wheel comprising:

5 A base including a push select shaft;

6 A scroll wheel assembly comprising:

7 A moveable scroll wheel for engagement by the user, the scroll wheel
8 comprising an internal gear provided within an interior of the scroll wheel;

9 An actuator comprising a drive shaft providing force to the scroll wheel in
10 response to movement of the scroll wheel;

11 a gear pinion coupled to the shaft and meshed with the internal gear; and

12 Sensing means for sensing movement of the scroll wheel;

13 A push select shaft guide in engagement with the push select shaft and
14 coupled to the scroll wheel assembly;

15 A tactile switch in engagement with the scroll wheel assembly; and

16 A control system coupled to the sensing means for receiving information
17 about positioning and movement of the scroll wheel, and also coupled to the actuator for
18 controlling force to the scroll wheel, the control system also providing control of the at least
19 one function of the motor vehicle system based upon the tactile switch and the scroll wheel.

1 17. A steering wheel system in accordance with claim 16 wherein the
2 actuator comprises a DC motor.

1 18. A steering wheel system in accordance with claim 16 wherein the
2 sensing means comprises an optical encoder comprising an optical encoder disk and an
3 emitter/detector.

1 19. A steering wheel system in accordance with claim 16 wherein the
2 sensing means comprises one of an analog potentiometer, a capacitive sensor, and a reflective
3 emitter/detector and encoder bar.

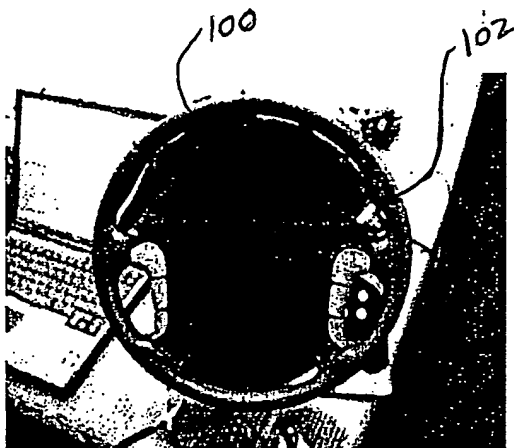


FIG. 1a

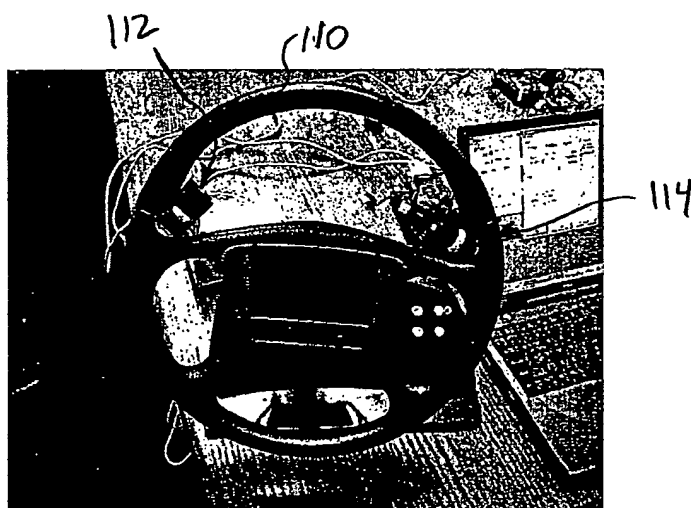


FIG. 1b



FIG. 1c

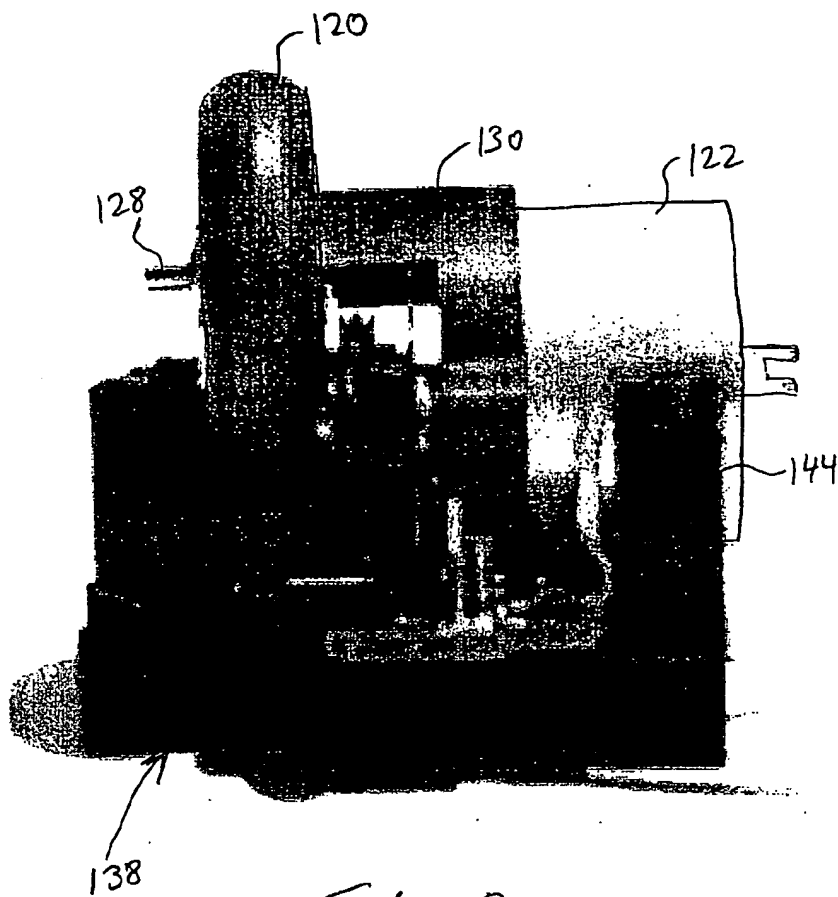


Fig. 2a

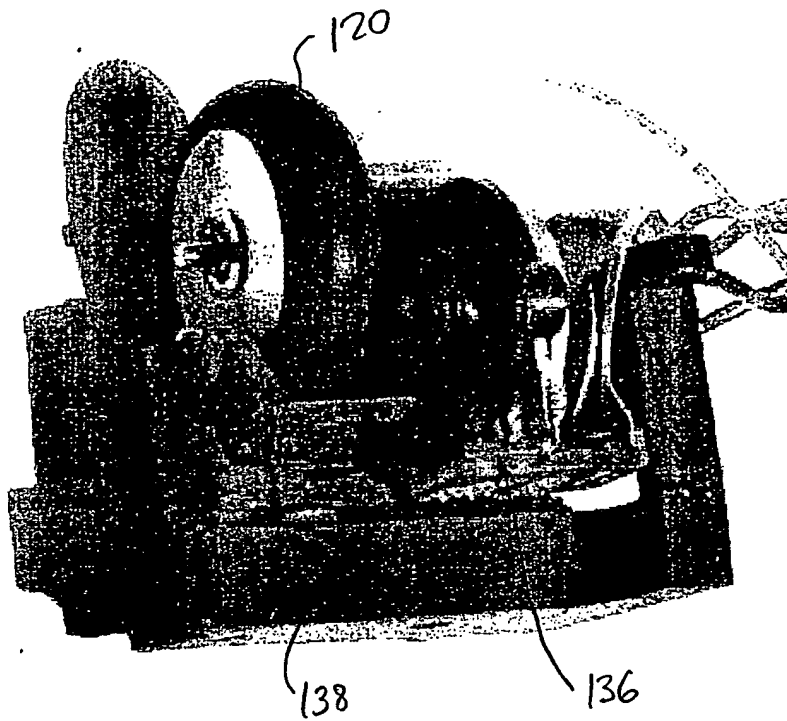


FIG. 2b

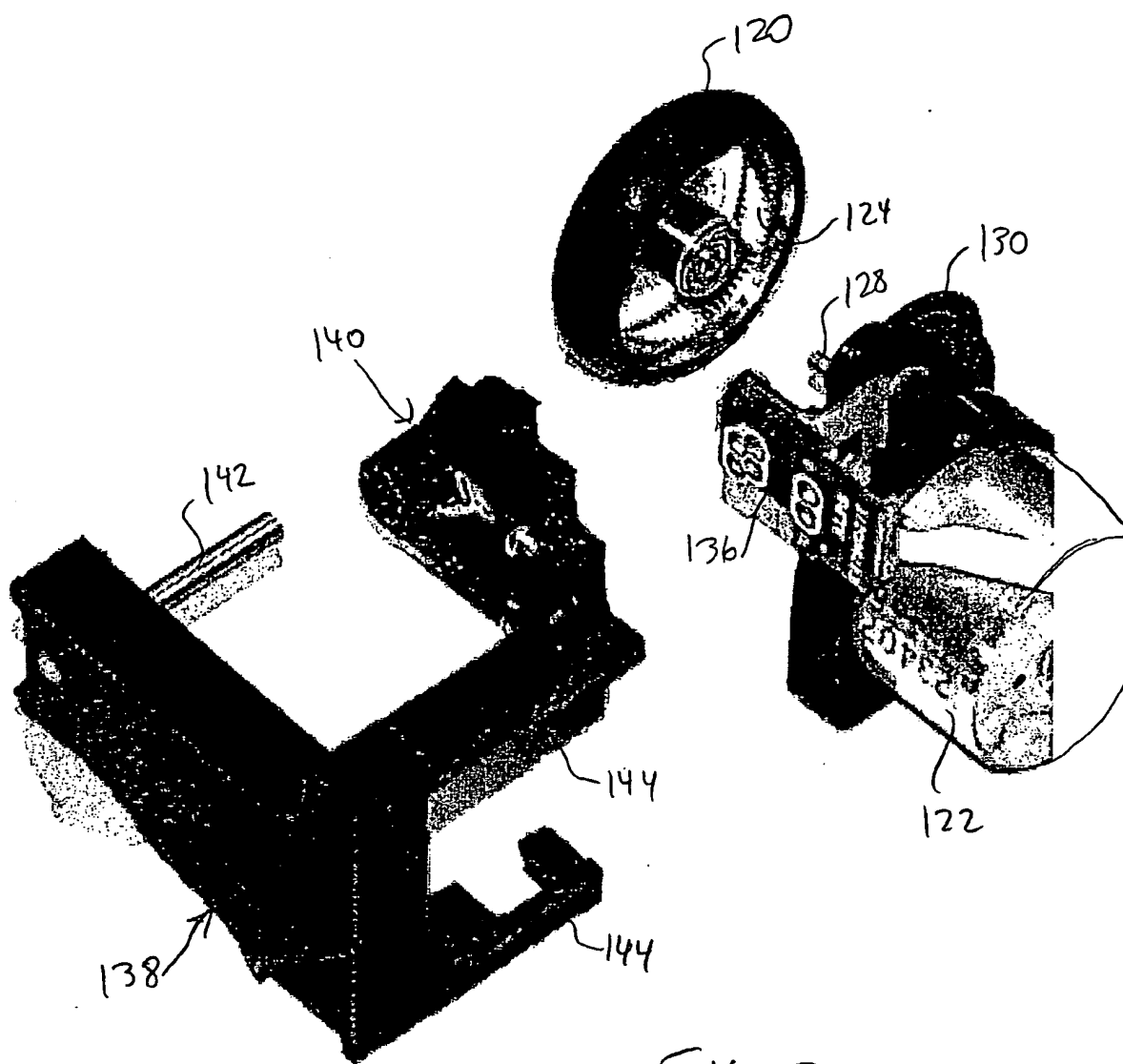


FIG. 2c

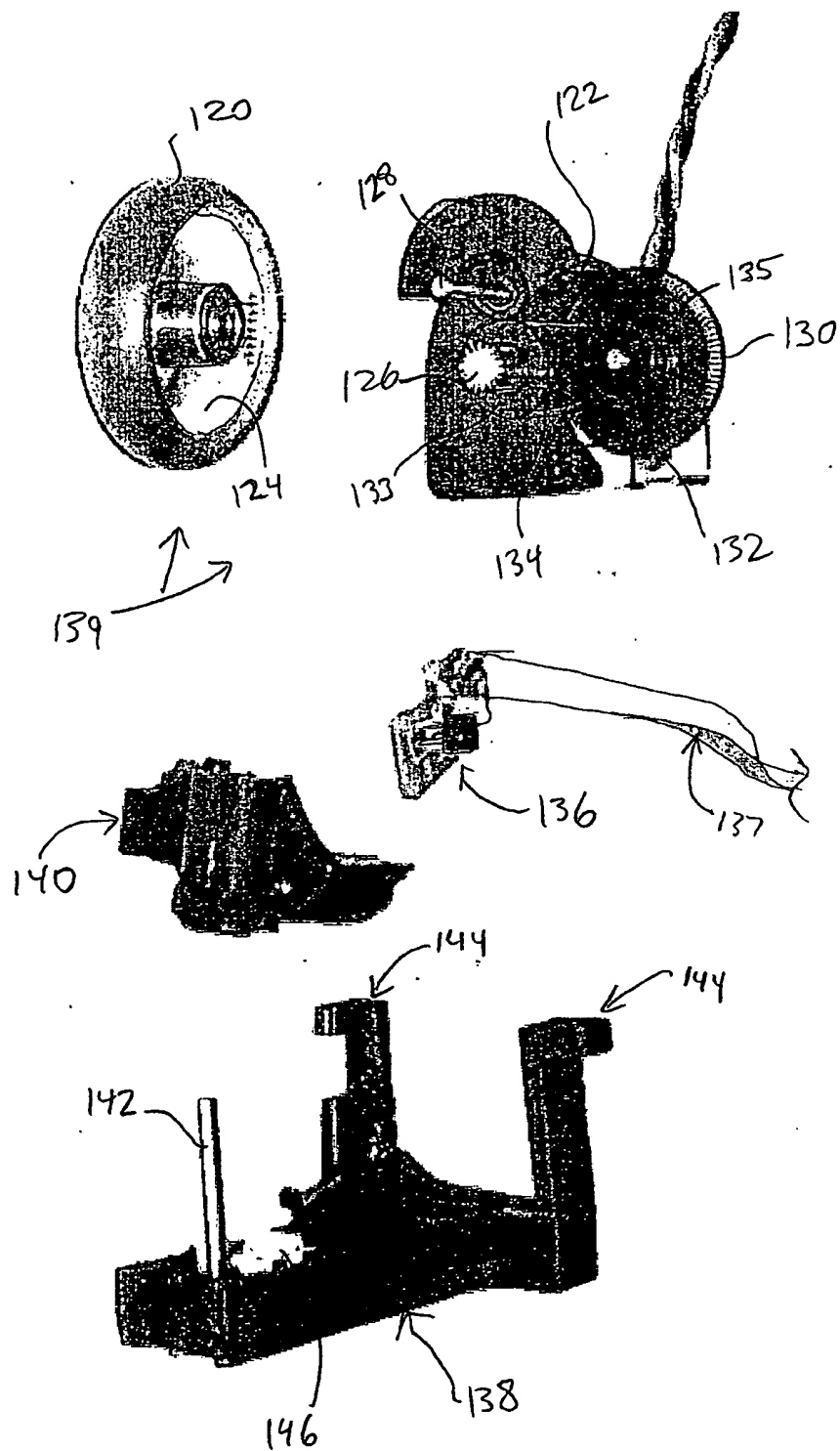


FIG. 2d

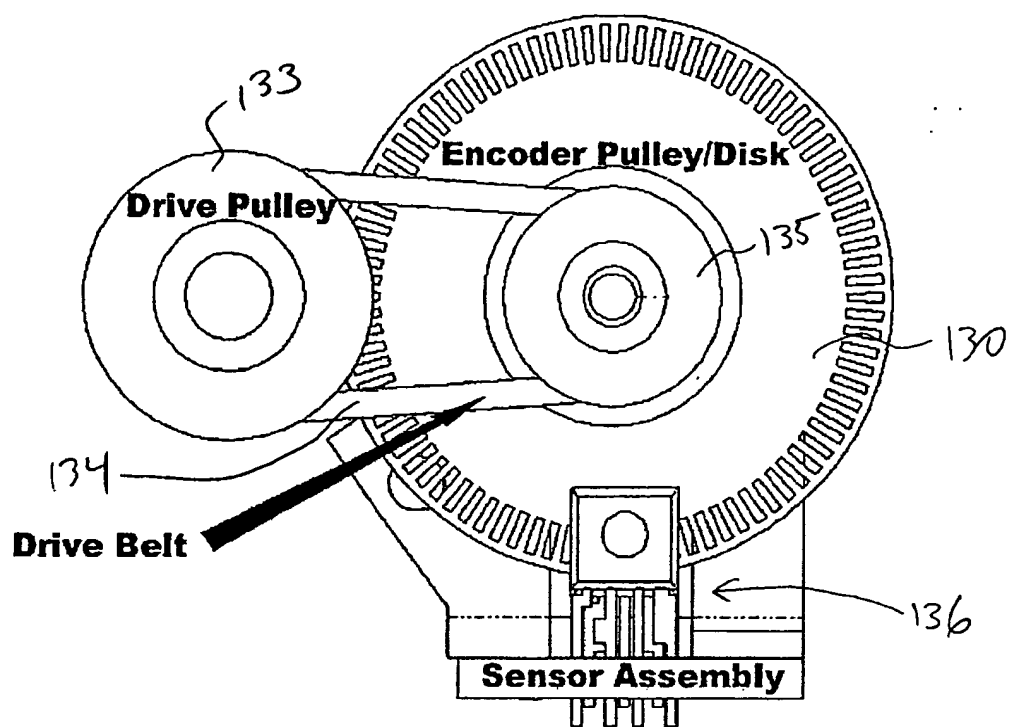


FIG. 2e

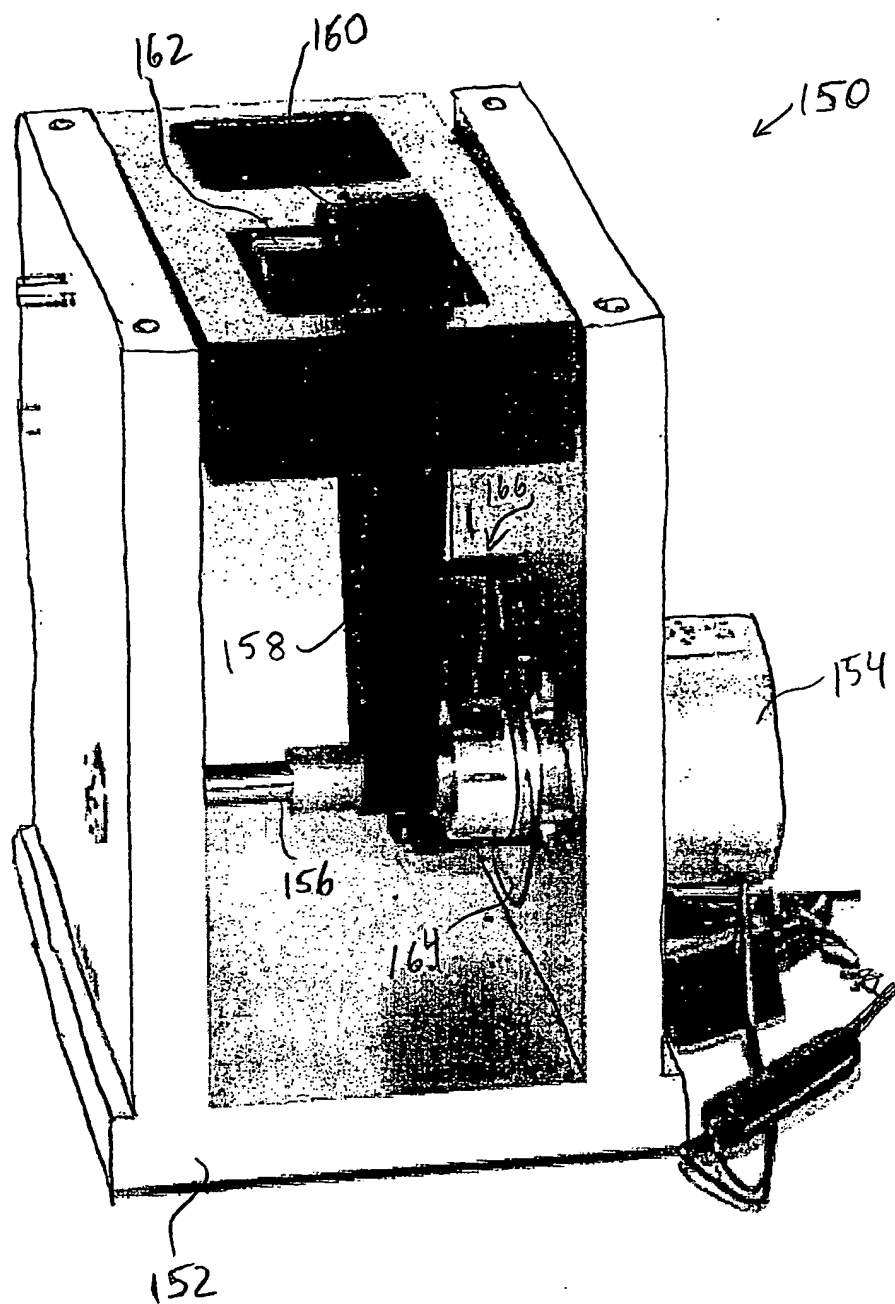


FIG 3

8/14

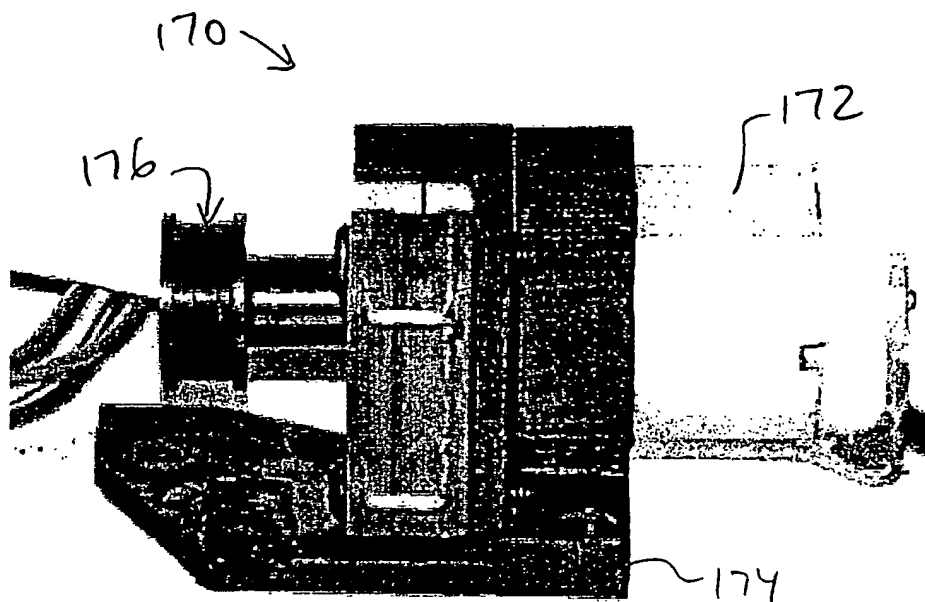


FIG. 4a

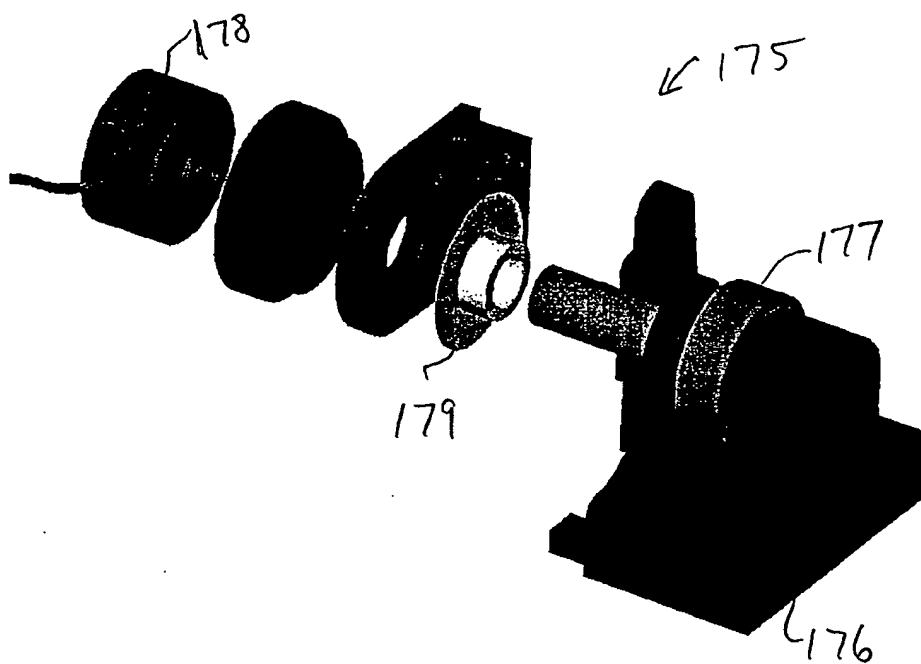


FIG. 4b

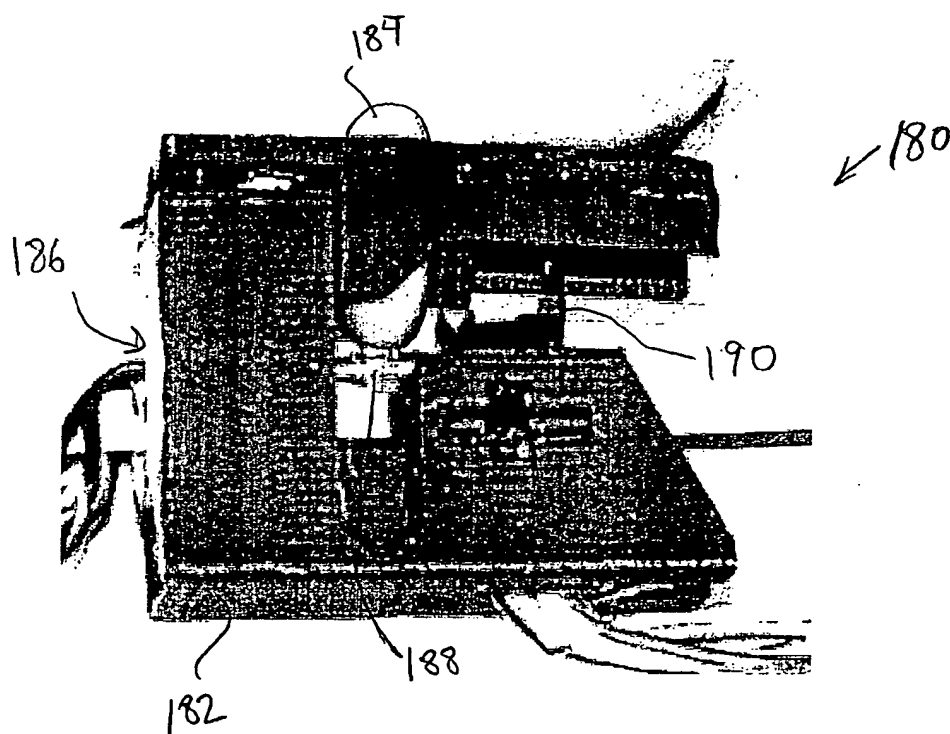
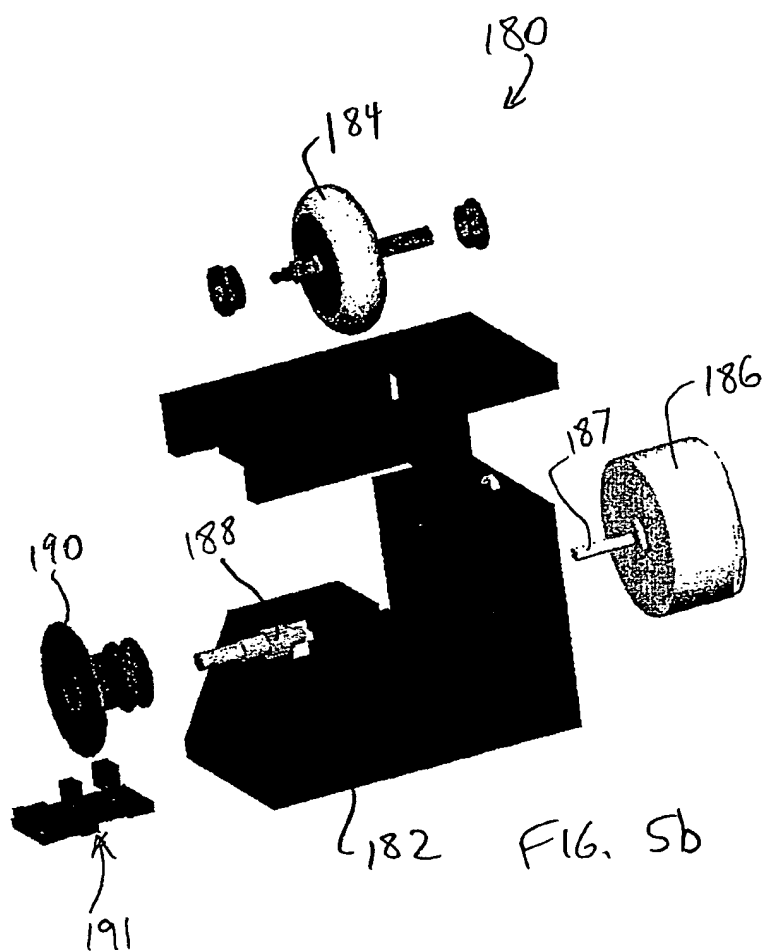
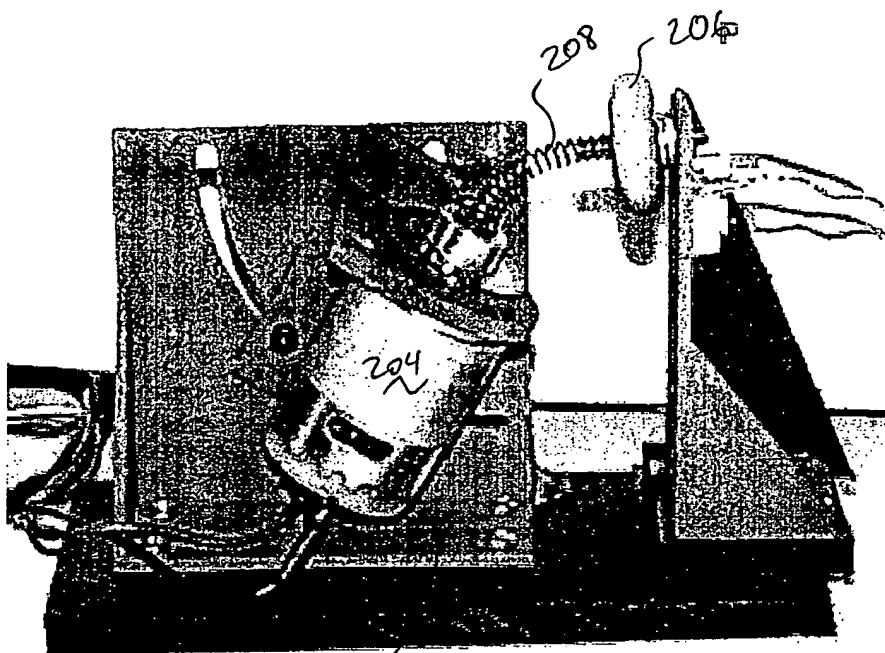


FIG. 5a





202

FIG. 6

200

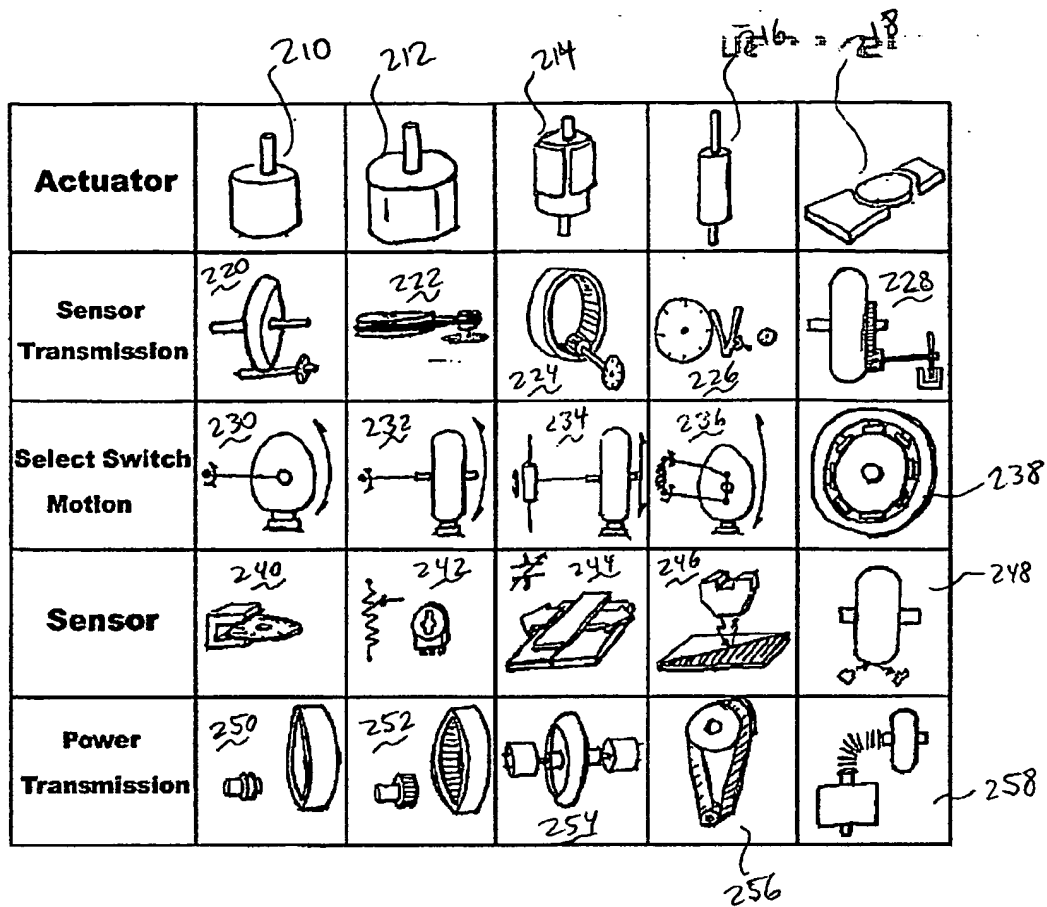


FIG. 7